TREETOPS Structural Dynamics and Controls Simulation System Upgrade

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The objective is to provide current and complete upgrade for the TREETOPS suite of analysis tools. TREETOPS is a time history simulation of the motion of a complex multibody flexible structure in a tree topology with active control elements. TREETOPS refers to the simulation program, TREETOPS plus two interactive preprocessors, TREESET and TREEFLX, an interactive postprocessor, TREEPLOT and an adjunct program, TREESEL.

The simulation provides an advanced capability for analyzing the dynamics and control-related issues of complex flexible structures. The code has been used to analyze and design controllers for a number of large space systems including the Hubble Space Telescope. TREETOPS is capable of simulating the dynamics and control of flexible systems as complex as the Space Station mission, the rendezvous and docking of spacecraft and the robot tasks and manipulations.

TREETOPS, a multibody dynamics and controls analysis tool, has undergone various upgrades to improve its applicability as well as modeling fidelity. These upgrades have included basic formulation enhancements as unrestricted boundary conditions for flexible bodies, accommodation of effects due to geometric nonlinearities, additions of sensor and actuator math models and revisions to increase computational performance. TREETOPS development efforts have been performed largely in a research and development environment, where the emphasis has been on adding analysis features to obtain numerical results. In a simulation development environment, emphasis has been placed on documentation and design details.

This upgrade will provide a format for maintaining the current tools as well as accommodations for future enhancements.

As part of the upgrades and enhancements, geometric nonlinearity was implemented. This implementation is of the general form of nonlinear foreshortening effects in TREETOPS. It gives rise to the theoretical background on nonlinear differential stiffness, motion stiffness and the generalized active force due to the foreshortening effects.

Test were done on beam-buckling and plate-buckling type problems to address the foreshortening effects. This enhancement offers a tremendous improvement to the analytical results.

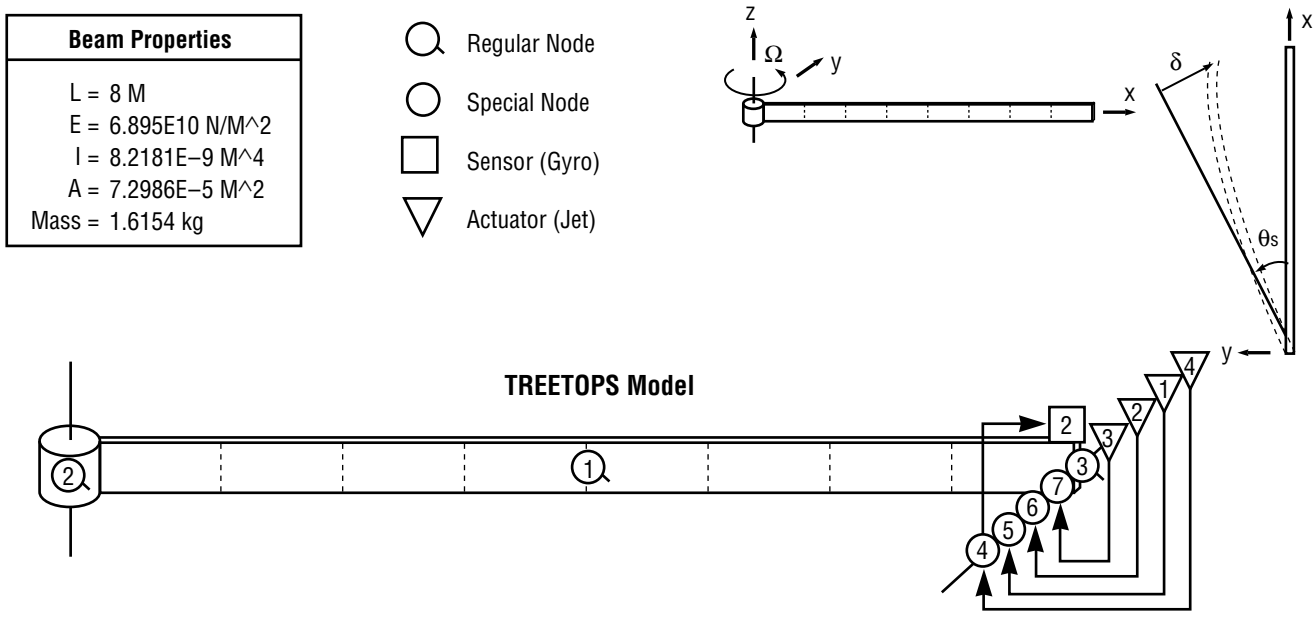

Figure 44.—TREETOPS model of spin-up beam.

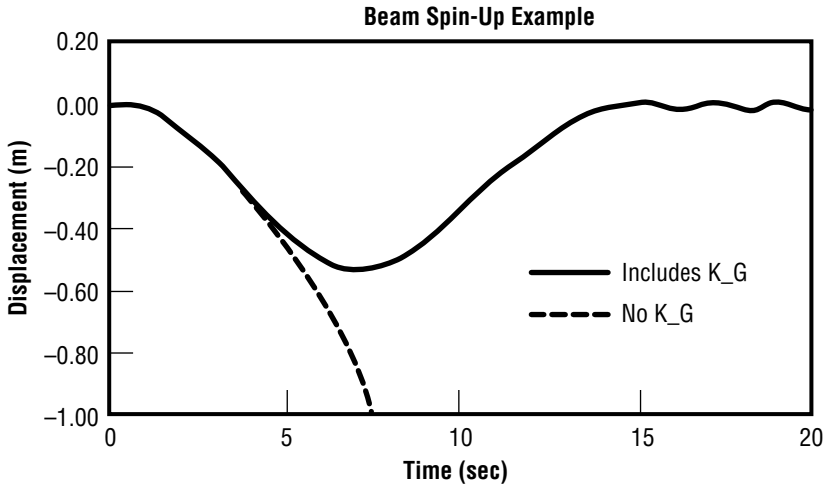

Figure 45.—Effect of geometric stiffening (K_G) on tip response.

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Other Involvement: Johnson Space Center, Goddard Space Flight Center, Langley Research Center, Stark Draper Laboratory, Sandia National Laboratory, Oak Ridge National Laboratory

Biographical Sketch: George Myers has a B.S. and M.S. in applied mathematics with 16 years of experience in control systems. He has experience in structural dynamics, control system design and attitude control of multibody systems. He has over 10 years of experience in multibody modeling for large space structures. He has coordinated activities related to TREETOPS with universities and the aerospace industry, in the field of multibody modeling. He has served as the focal point for TREETOPS multibody modeling activities for over 10 years.